

DSN Tracking System Uplink Frequency Control

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The failure of the Voyager 2 spacecraft receiver requires that the DSN maintain the communications link to the spacecraft by constantly tuning the uplink frequency to null the effects of doppler. The following article discusses the planned implementation within the DSN Tracking System to automate this current manual process.

I. Introduction

The failure of the Voyager 2 receiver eliminated the ability of this spacecraft to maintain lock on the Deep Space Station generated uplink frequency, as this frequency is shifted by the time varying effects of doppler. Healthy spacecraft receivers do track the uplink signal, and thus it is standard practice within the DSN to select an uplink frequency that is fixed for a given station view period, and is the predicted spacecraft best-lock frequency (the frequency that results in the quickest acquisition by the unstressed spacecraft receiver), modified by the average doppler effect to be experienced during the station view period.

This standard practice cannot be used for Voyager 2 tracks. Instead, the uplink is sustained by constantly tuning the station-transmitted frequency to compensate for the uplink doppler effect, and in effect provide the spacecraft receiver with a near-constant received frequency (± 25 Hz about the best-lock frequency at S-band). Following the receiver failure, procedures and software were hastily developed and put to use to provide the needed communications link with the spacecraft.

These procedures and software were developed to support an emergency spacecraft condition and require continuous support by personnel at JPL and at the supporting station. The numerous points at which human intervention are required and the resulting susceptibility to errors are the major motivating factors behind the implementation of automated uplink frequency control at the station. This implementation is described in the following sections. Figure 1 provides a simplified block diagram of the uplink frequency control implementation.

II. DSS Subsystems

The urgently needed relief from the burden on operations personnel in manually executing the required uplink frequency control sequences dictated that the implementation be accomplished as quickly as possible; and further, that existing capabilities be utilized to the fullest extent possible to avoid the lengthy evolution of wholly new hardware and software. This was the guiding philosophy for the uplink frequency control implementation within the station subsystems, as well as the Network Operations Control Center (NOCC) subsystems at JPL.

A. The Receiver-Exciter Subsystem

A digital frequency controller, the Programmed Oscillator Control Assembly (POCA), was developed several years ago as part of the Block IV receiver-exciter implementation. The high utility of this device has led to its deployment throughout the Network. The POCA is the key component in the existing uplink frequency control capability. However, it also represents the focal point of most errors made in supporting the uplink, as POCA programming is accomplished by manually entering frequencies, times, and tuning rates. This manual activity must be carried on throughout all Voyager 2 tracks as the POCA does not have sufficient storage to accommodate all parameters necessary to sustain uplink frequency control for the duration of a station track. Not infrequently an error is made in the entry of POCA control parameters.

The automated uplink frequency control implementation will also utilize the POCA. However, operator entries will be eliminated with the establishment of an interface between the POCA and the Metric Data Assembly (MDA). Entries to the POCA will be made automatically by this assembly. In addition, this assembly will advance load the POCA storage registers to maximize the length of time that the uplink may be sustained in the event of a failure of either this assembly or its interface to the POCA.

Manual control of the POCA – should it be necessary – will be provided via a central station control terminal, the Data System Terminal (DST). Feedback of the status of the POCA will be provided to the MDA and DST. A report of frequency, frequency rate, and status are included in the radio metric data stream.

A new digital controller is scheduled to make its debut in the Network about August 1980. This new controller includes increased storage capacity, and will become the prime exciter controller in the 64- and 34-meter subnets. The POCA will be retained at these stations as a backup. The 26-meter Network will not be equipped with either POCAs or the new controllers. Use of the new controller will not functionally alter the uplink frequency control implementation. Figure 2 depicts the planned uplink frequency control capability throughout the Network.

B. The DSS Tracking Subsystem

As mentioned earlier, the MDA plays a key role in uplink frequency control implementation by providing the Receiver-Exciter Subsystem with frequency control parameters. These

parameters, based upon uplink frequency control predicts, consist of a start tuning frequency, and frequency rate and time pairs that model in a piece-wise linear fashion, the profile of the doppler modified best-lock frequency.

A significant time and effort savings was realized in implementing this capability in the MDA by virtue of a functionally similar capability recently implemented in the Radio Science System. The Radio Science System implementation included development of a new module of the prediction program designed specifically to support frequency control using a POCA, as well as the logic and algorithms necessary to process the predictions and interface with the POCA.

For the uplink frequency control implementation, the prediction processing and interface logic were modified to provide improved reliability by minimizing dependence on the MDA by the Receiver-Exciter Subsystems. Changes were made in the storage of predicts; the MDA will store three sets of control predicts, each set consisting of eight days of predictions. The MDA will also provide feedback to JPL regarding the successful reception of predictions via the High-Speed Data Subsystem. A local station hard copy of the uplink frequency control predictions as received by the MDA will be provided.

The MDA will provide reports via the radio metric data stream of the POCA status and commanded frequency tuning rate any time a change in either status or rate is detected. These parameters are necessary for both monitoring the performance of the station and for the orbit determination process where the frequency rates caused by tuning must be separated from those of the relative earth-spacecraft motion. Also to be provided in the radio metric data stream are the identification of the predicts set in use for frequency control, and any frequency or time biases that may have been centered to offset this predicts set.

C. The Network Operations Control Center (NOCC) Tracking Subsystem

As previously mentioned, a module of the prediction software implemented to support the Radio Science System was designed to fit linear segments to a given ground received frequency profile. It generates values of frequency and time pairs that approximate the given profile within specified limits and assures that this can be accomplished within the precision limits of the POCA. This is exactly the capability needed for the uplink frequency control implementation. Thus the only change required to the prediction software is to create a new predicts type for uplink frequency control and a new station

destination code. Thus, when uplink frequency control predicts are transmitted to the station they will be routed automatically to the MDA. The actual generation of the data to be transmitted will be accomplished without modification to the existing predicts program algorithm. The frequency, frequency profile, curve fitting constraints, and time spans are all operator controlled inputs.

The Tracking Subsystem Real-Time Monitor (RTM) will provide display of predicts reception and acknowledge messages generated by the MDA. The RTM will also provide volatile displays to the Network Operations Control Team (NOCT) and project users of the POCA status, and the commanded uplink frequency tuning rates. These parameters

will also be incorporated into the System Performance Record for more detailed nonreal-time analysis.

III. Summary

The Voyager 2 spacecraft receiver failure requires that the Deep Space Stations continuously tune the uplink frequency to compensate for the effects of doppler. This process is currently accomplished through a process that requires extensive human intervention and is error prone. An implementation within the DSN Tracking System will provide automated uplink frequency control by using electrical interfaces to control the transmitted frequency directly from predictions.

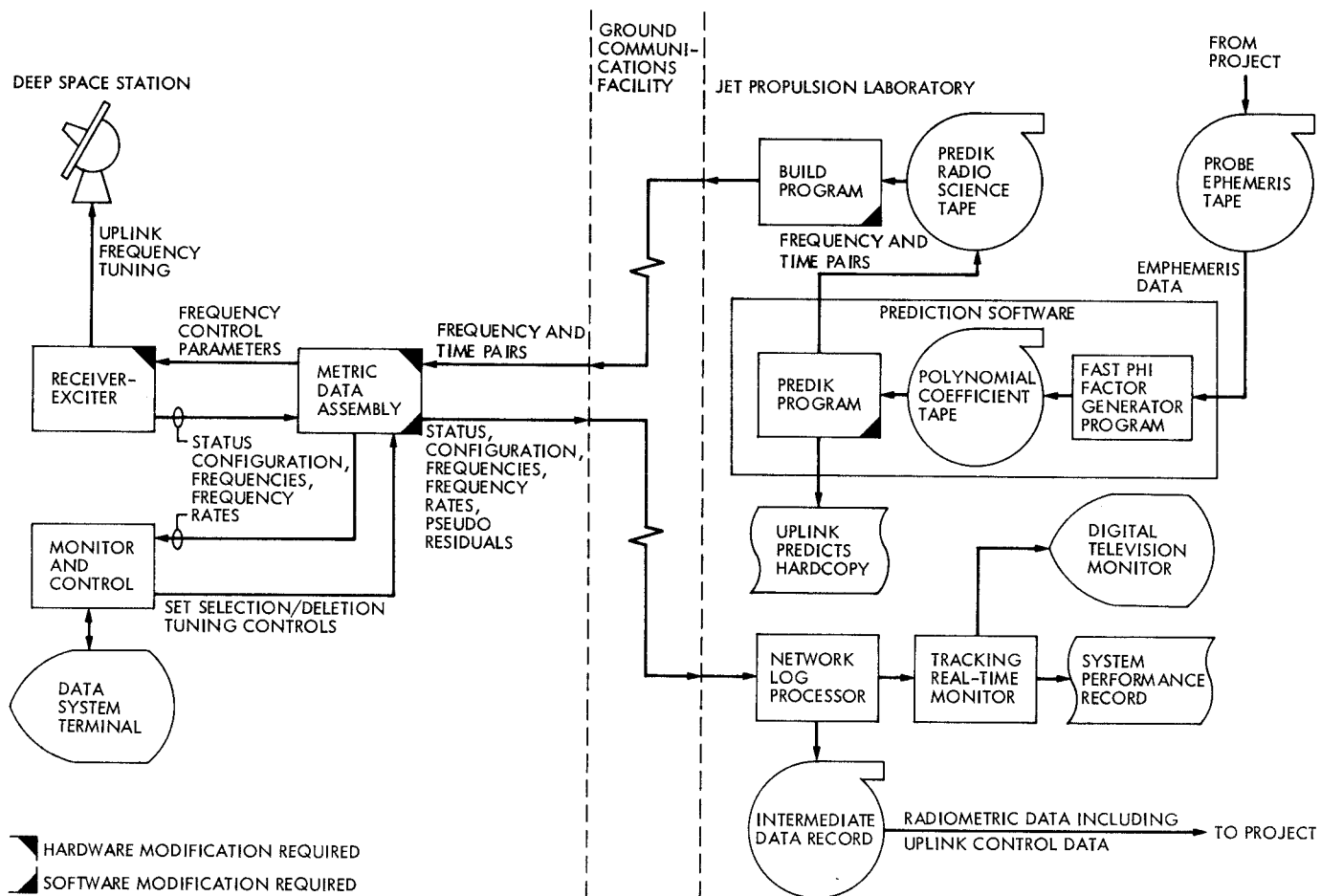



Fig. 1. Uplink frequency control functional block diagram

NETWORK	DEEP SPACE STATION	1979					1980												1981							
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
64-METER	14	DANA + POCA + SMC					DANA + POCA + MDA												VOYAGER 1 SATURN ENCOUNTER					VOYAGER 2 SATURN ENCOUNTER		
	43																									
	63																									
34-METER	12	DANA + POCA																								
	42																									
	61																									
26-METER	11	DANA* + POCA*					DANA* + POCA* + MDA												HP** + SMC							
	44	HP**					DANA + POCA																			
	62	HP** + SMC																								

* DEVELOPMENT LAB UNITS IN DSS 11
 ** HP FOR FIXED FREQUENCY, NO RAMPING

HP HEWLETT-PACKARD SYNTHESIZER
 DANA DANA SYNTHESIZER
 POCA PROGRAMMED OSCILLATOR CONTROL ASSEMBLY
 MDA METRIC DATA ASSEMBLY
 SMC STATION MONITOR AND CONTROL SUBSYSTEM

Fig. 2. Uplink control configurations